IES Institute of Education Sciences

2022 IES PI Meeting

Exploring Direct Observation Data Within an IES-Funded Efficacy Trial

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Agenda

- Case for the Research
- Active Ingredients of Interventions
- ROOTS Efficacy Project
- ROOTS Observation System
- Findings
- Discussion

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ROOTS Project Members

- **Principal Investigators & Methodology**
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- **Project Coordination**
  Cindy Sprague
- **Curriculum Design**
  Kathy Jungjohann & Karen Seitz
- **Graduate Research Assistants**
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The Advancements of Education Science

- The research agendas of prominent federal funding agencies have moved the field forward by **leaps** and **bounds** (Morris & Reardon, 2017)

- Since its advent in 2002, IES has invested **~$3 billion** in total grant funding, with **nearly 33%** of that spending devoted toward rigorous **causal inference** research studies, such as randomized controlled trials (Chhin et al., 2018).

- Primary focus of such research is to answer questions about student response to educational interventions (i.e., ***what works*** and ***doesn't work***)

Moving Beyond What Works

- "**What works**" information is integral for building the knowledge base on effective educational interventions.

- However, ***alone it is insufficient*** to ascertain why an intervention works, for whom, and under what conditions.

- Explicating how or why an intervention produces treatment effects (i.e., positive or null) requires investigating its ***active ingredients.***

Let the Job of Unpacking Begin!

- Active ingredients represent the ***theoretically-specified mechanisms*** (mediators) through which interventions operate.
- Exploring an intervention's active ingredients may increase a research group's capacity to ***unpack its black box*** (Miller et al., 2014; Reardon et al., 2011).
- Unpacking these black boxes can help the field ***improve the outcomes*** of students who demonstrate academic risk, especially those from marginalized and underserved communities.

Active Ingredients Targeted in our Early STEM Research Program

- Our research team has explored ***instructional interactions*** in **4 IES-funded Efficacy Trials** and **1 Exploration Project** to gain deeper insight into our early STEM interventions:
  - Treatment intensity (Codding & Lane, 2015; Warren et al., 2007)
  - Response variation (Clarke et al., 2019; Fuchs & Fuchs, 2019)

Why Instructional Interactions?

- Even with rigorous content standards, pedagogically savvy teachers, well-designed and delivered interventions, and psychometrically-sound assessments, arguably, it is the ***instructional interactions*** that take place in the classroom that ***matter most*** (NRC, 2001).

Explicit Instructional Interactions

- Explicit instructional interactions represent a dynamic interplay:
  - *Teacher demonstrations / explanations* of academic content
  - *Student practice opportunities* (individual and group)
  - *Academic feedback* (timely and specific)

- Such explicit instructional interactions are ***public*** and ***observable***, and therefore can be ***interpreted via direct observations.***

Purpose of the Research

- Determine whether **explicit instructional interactions** have **explanatory power** contributing to the improvement of student mathematics outcomes within the **treatment condition** (ROOTS).

Article

Measuring the Quantity and Quality of Explicit Instructional Interactions in an Empirically Validated Tier 2 Kindergarten Mathematics Intervention

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Abstract

Instructional interactions that occur between teachers and students around foundational mathematics topics are critical for supporting mathematical proficiency among students with mathematics learning disabilities (MLD). This study investigated whether the initial mathematics skill of 880 kindergarten students at risk of MLD predicted the quantity and quality of explicit instructional interactions (i.e., overt teacher modeling, student practice opportunities, and academic feedback) experienced during an empirically validated Tier 2 kindergarten mathematics intervention. It also examined whether the quantity and quality of such instructional interactions predicted gains in student mathematics achievement. Researchers conducted 740 direct observations of 255 intervention groups within a multiyear, randomized controlled trial. Results suggested that intervention groups with lower initial mathematics skill received higher rates of academic feedback and made more frequent errors. In addition, more frequent and higher quality academic feedback and group practice opportunities predicted increased mathematics achievement. Implications for investigating the active ingredients of mathematics interventions are discussed.

Keywords

instructional interactions, explicit instruction, mathematics difficulties, efficacy research, randomized controlled trial, mathematics learning disabilities, direct observation

A consistent finding of methodologically rigorous research is that explicit instruction leads to better student achievement for students who demonstrate academic risk (Agodini & Harris, 2010; Gersten et al., 2009; Vaughn & Swanson, 2015). In addition to helping establish the efficacy of explicit instruction, this body of empirical work has also begun to build consensus on the particulars of this instructional approach. It is evident from this literature base, for example, that explicit instruction is a systematic approach that utilizes empirically validated instructional design and delivery principles to unambiguously teach fundamental concepts and skills that students would not otherwise acquire on their own (Hughes, Morris, Therrien, & Benson, 2017). This instructional approach also scaffolds instruction to promote a high success rate among at-risk students (Rosenshine, 2012).

Explicit instruction is known to facilitate purposefully designed instructional interactions for students to learn foundational mathematics content (Hughes et al., 2017). Such interactions include overt teacher modeling, structured opportunities for students to practice with mathematical concepts, and teacher-provided academic feedback. Research conducted in core (Tier 1) mathematics settings suggests that early elementary students (i.e., kindergarten to second grade) benefit most from classrooms that offer more frequent explicit instructional interactions around critical mathematics concepts and skills (Clements, Agodini, & Harris, 2013; Doabler et al., 2015). Despite evidence that the explicit instructional interactions that occur between teachers and students in Tier 1 settings matter, little is known about how students with or at risk of mathematics learning disabilities (MLD) engage in mathematical content in Tier 2 mathematics interventions.

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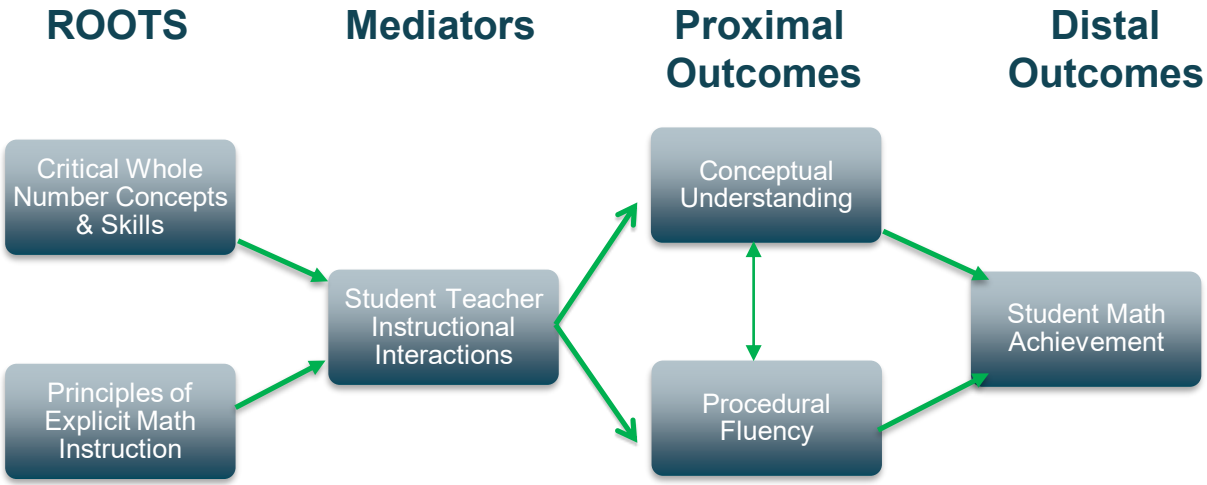
The ROOTS Mathematics Project (2012-2017)

- IES-funded Efficacy Trial focused on the impact of the **ROOTS intervention**.
  - Small-group, kindergarten math intervention (number sense)
  - ~1,250 kindergarteners from 138 classrooms in OR. and MA.
- Employed a **partially nested** randomized controlled trial (Baldwin et al., 2011)
  - ROOTS Small Group (2:1 student teacher ratio)
  - ROOTS Large Group (5:1 student teacher ratio)
  - No treatment control – core math instruction only

ROOTS

- Formed 255 ROOTS groups w/ 880 kindergarteners with math difficulties (MD)
- All students continued to receive Tier 1 core math instruction.

ROOTS Theory of Change



Direct Observations of ROOTS

- Trained staff conducted **740 real-time observations** of **255 ROOTS groups**
  - Aimed to observe each ROOTS group 3x across 10 week period
  - Completed 97% of planned observations
  - 139 (19%) inter-observer reliability checks
  - Average observation (~21 min.)

- Employed a ***multifaceted*** direct observation system that targeted the ***quantity*** and ***quality*** of ***instructional interactions***.

ROOTS Observation System: Two Tools

COSTI-M: (Quantity)[1]

- Low-inference tool
- Captures the frequency of:
  - Teacher demonstrations
  - Individual student practice opps.
  - Group student practice opps.
  - Academic feedback
  - Student mistake

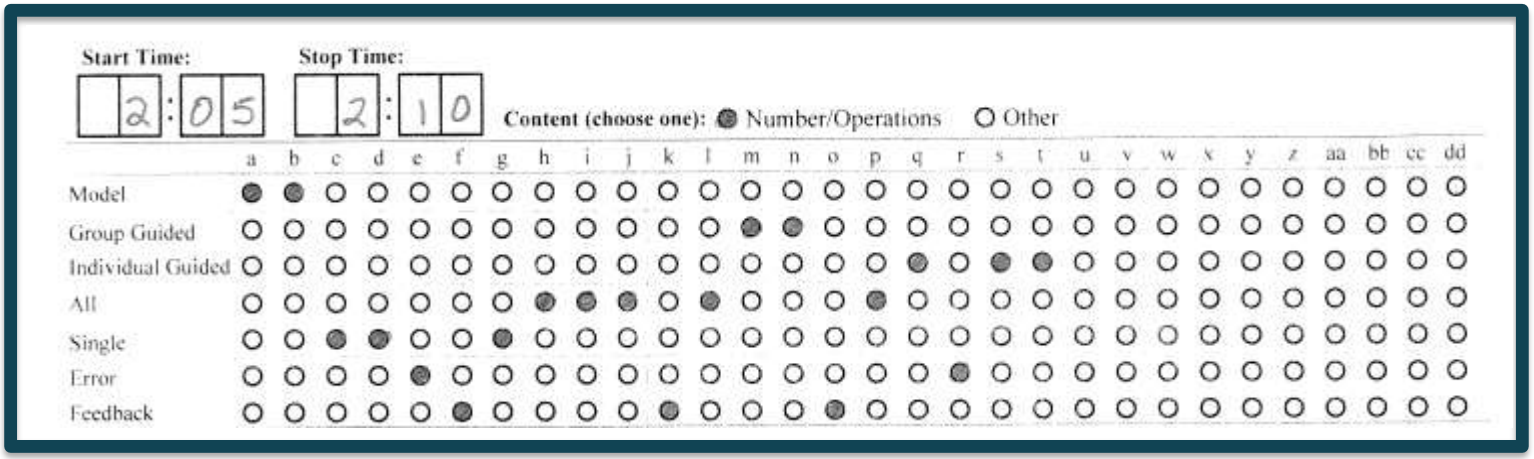
[1]*Note*: (Doabler et al., 2015; Gunn et al., 2021; Smolkowski & Gunn, 2012)

QEMI: (Quality)[2]

- Moderate-inference tool
- Likert type rating scale (1-4)
- 7 items focused on quality of:
  - Teacher demonstrations
  - Individual student practice opps.
  - Group student practice opps.
  - Student participation
  - Academic feedback
  - Instructional scaffolding
  - Efficiency of instruction

[2]*Note*: (Doabler & Clarke, 2012)

COSTI-M: Close Up



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Methodology & Findings

1. Inter-observer Reliabilities
2. Stability of Instructional Interactions
3. Associations between Instructional Interactions and Mathematics Outcomes

Inter-observer Reliabilities

- Degree to which individual observers provide the same information
- Multilevel model with observers (i) nested within observation occasions (j):

$$\text{Level 1: } \text{ObsScore}_{ij} = \beta_{0j} + r_{ij}, \quad r_{ij} \sim N(0, \sigma^2)$$
$$\text{Level 2: } \beta_{0j} = \gamma_{00} + u_{0j,} \quad u_{0j} \sim N(0, \tau^2)$$

$$\text{Reliability ICC} = \tau 2 / (\tau 2 + \sigma 2)$$

Inter-observer Reliability Results

Interobserver Reliability ICCs: Observers (i) nested within observation occurrence (j)

	Variance		Reliability
Observation Measure	Within (σ^2)	Between (τ^2)	ICC
Teacher demo rate	0.02	0.05	**0.72**
Individual practice rate	0.10	1.52	**0.94**
Group practice rate	0.06	0.88	**0.94**
Student mistake rate	0.01	0.05	**0.82**
Feedback rate	0.04	0.43	**0.91**
QEMI Score	0.05	0.38	**0.89**

Note. ICCs < .50 is poor, .50 to .75 is moderate, .75 to .90 is good, and > .90 is excellent (Koo & Li, 2016)

ROOTS Group Stability

- Degree to which behaviors were stable across observation occasions
- Model with observation occasions (i) nested within ROOTS groups (j):

$$\text{Level 1: } \text{ObsScore}_{ij} = \beta_{0j} + r_{ij}, \quad r_{ij} \sim N(0, \sigma^2)$$
$$\text{Level 2: } \beta_{0j} = \gamma_{00} + u_{0j,} \quad u_{0j} \sim N(0, \tau^2)$$

$$\text{Stability ICC} = \tau 2 / (\tau 2 + \sigma 2)$$

ROOTS Group Stability Results

Stability ICCs: Observations (i) nested within ROOTS groups (j)

Observation Measure	Variance		Stability ICC	Reliability of the Mean
	Within (σ^2)	Between (τ^2)		
Teacher demo	0.05	0.01	**0.14**	**0.33**
Individual practice rate	1.08	0.27	**0.20**	**0.43**
Group practice rate	0.60	0.22	**0.26**	**0.52**
Student mistake rate	0.04	0.01	**0.20**	**0.43**
Feedback rate	0.30	0.19	**0.39**	**0.66**
QEMI Score	0.21	0.17	**0.45**	**0.71**

Note. ICCs > .50 need no more than 3 observations per ROOTS group. ICCs from .20 to .50 require 3 to 6 observations per group (Shoukri et al., 2004)

Associations with Math Outcomes

- **Research Question 1**: Does initial math achievement predict the quantity and quality of explicit instructional interactions?
- **Research Question 2**: Does the quantity and quality of instructional interactions predict gains in math achievement?
- Multilevel model with assessments (Level 1) nested within Students (Level 2) and ROOTS groups (Level 3):

$$\text{Level 1:} \quad Y_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{Time}) + e_{ijk}$$

$$\text{Level 2:} \quad \pi_{0jk} = \beta_{00k} + r_{0jk}$$

$$\pi_{1jk} = \beta_{10k} + r_{1jk}$$

$$\text{Level 3:} \quad \beta_{00k} = \gamma_{000} + \gamma_{001}(\text{ObsScore}) + u_{00k}$$

$$\beta_{10k} = \gamma_{100} + \gamma_{101}(\text{ObsScore}) + u_{10k}$$

Mixed:

$$Y_{ijk} = \gamma_{000} + \gamma_{001}(\text{ObsScore}) + \gamma_{100}(\text{Time}) + \gamma_{101}(\text{ObsScore} \times \text{Time}) + e_{ijk} + r_{0jk} + u_{00k} + u_{10k}(\text{Time}) + r_{1jk}(\text{Time})$$

Associations with Math Outcomes (Results)

Results Summary for Research Questions 1 and 2

	Research Question 1 (associations with pretest)		Research Question 2 (associations with gains)	
	RAENS	ASPENS	RAENS	ASPENS
Teacher demo	.000	.000	.001	.000
Individual practice rate	.000	.000	(-) .011	(-) .020*
Group practice rate	.001	.001	.063***	.053***
Student mistake rate	(-) .037**	(-) .012	(-) .028**	(-) .129***
Feedback rate	(-) .041**	(-) .023*	.062***	.034**
QEMI Score	.003	.001	.026*	.028**

Table entries show r^2 equivalent for γ_{001} (Research Question 1) and γ_{101} (Research Question 2).

*$p < .05$, **$p < .01$, ***$p < .001$

Discussion

- Current findings align with those from our other IES-funded work:
  - **Project Fusion** (Doabler, Clarke et al., 2021) found significant associations between gains in student math outcomes and high rates of group practice opportunities and academic feedback.
    - Implications for teachers who work with students with or at risk for MD.
  - **Projects CIFOR** (Doabler et al., 2017), **ELM** (Doabler et al., 2015) and **Fusion** (Doabler et al., 2021) all reported similar signs of "unstable" instruction interactions
    - Future efforts needed to grasp this volatility or day-to-day variability

Conclusion

- Observation research can be **challenging** and **expensive**, particularly when situated in larger efficacy trials
  - Competing priorities
  - Cost of real-time observations
  - Geographical distance between participating sites

- Future observation research plans within our efficacy work
  - Audio recordings: address stability of observation measures
  - Teachers' instructional adjustments (local adaptations)
  - Student practice opportunities (e.g., scaffolded vs. independent)

Questions

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